

Fishery Data Series No. 17-06

Alexander Creek Chinook and Coho Salmon Stock Assessment, 2014 and 2015

by

Adam St. Saviour

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Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries



Symbols and Abbreviations

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Weights and measures (metric)		General		Mathematics, statistics	
centimeter	cm	Alaska Administrative Code	AAC	all standard mathematical signs, symbols and abbreviations	
deciliter	dL	all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.	alternate hypothesis	H _A
gram	g	all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	<i>e</i>
hectare	ha			catch per unit effort	CPUE
kilogram	kg			coefficient of variation	CV
kilometer	km	at	@	common test statistics	(F, t, χ^2 , etc.)
liter	L			confidence interval	CI
meter	m			compass directions:	correlation coefficient
milliliter	mL	east	E	(multiple)	R
millimeter	mm	north	N	correlation coefficient	
Weights and measures (English)		south	S	(simple)	r
cubic feet per second	ft ³ /s	west	W	covariance	cov
foot	ft	copyright	©	degree (angular)	°
gallon	gal	corporate suffixes:		degrees of freedom	df
inch	in	Company	Co.	expected value	<i>E</i>
mile	mi	Corporation	Corp.	greater than	>
nautical mile	nmi	Incorporated	Inc.	greater than or equal to	≥
ounce	oz	Limited	Ltd.	harvest per unit effort	HPUE
pound	lb	District of Columbia	D.C.	less than	<
quart	qt	et alii (and others)	et al.	less than or equal to	≤
yard	yd	et cetera (and so forth)	etc.	logarithm (natural)	ln
Time and temperature		exempli gratia		logarithm (base 10)	log
day	d	(for example)	e.g.	logarithm (specify base)	log ₂ , etc.
degrees Celsius	°C	Federal Information Code	FIC	minute (angular)	'
degrees Fahrenheit	°F	id est (that is)	i.e.	not significant	NS
degrees kelvin	K	latitude or longitude	lat or long	null hypothesis	H ₀
hour	h	monetary symbols		percent	%
minute	min	(U.S.)	\$, ¢	probability	P
second	s	months (tables and figures): first three		probability of a type I error	
Physics and chemistry		letters	Jan,...,Dec	(rejection of the null hypothesis when true)	α
all atomic symbols		registered trademark	®	probability of a type II error	
alternating current	AC	trademark	™	(acceptance of the null hypothesis when false)	β
ampere	A	United States		second (angular)	"
calorie	cal	(adjective)	U.S.	standard deviation	SD
direct current	DC	United States of America (noun)	USA	standard error	SE
hertz	Hz	U.S.C.	United States Code	variance	
horsepower	hp			population sample	Var
hydrogen ion activity (negative log of)	pH	U.S. state	use two-letter abbreviations (e.g., AK, WA)		var
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

FISHERY DATA SERIES NO. 17-06

**ALEXANDER CREEK CHINOOK AND COHO SALMON STOCK
ASSESSMENT, 2014 AND 2015**

by
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February 2017

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ABSTRACT

Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) were enumerated in 2014 and 2015 using a resistance board weir at river kilometer 21 of Alexander Creek in the Northern Cook Inlet Management Area. Only the coho salmon run was fully censused in 2014; both the Chinook and coho salmon runs were fully censused in 2015. In 2014, the total coho salmon escapement to Alexander Creek was 191 fish; the midpoint of the run was August 17. The dominant age class of the 2014 coho salmon run was 2.1 (93.9%, SE 1.7%). In 2015, the total coho salmon escapement to Alexander Creek was 266 fish; the midpoint of the run was August 17. Coho salmon were not aged in 2015. In 2015, the total Chinook salmon escapement to Alexander Creek was 2,152 fish; the midpoint of the run was June 27. The dominant age classes of the 2015 Chinook salmon run were 1.2 (44.2%, SE 6.9%) and 1.3 (46.2%, SE 6.9%). In 2015, a Chinook salmon aerial count not associated with this project was the greatest since 2005. This and the weir count support the idea that age-1.3 Chinook salmon and younger that returned in 2015 benefitted from rearing in Alexander Creek when a northern pike suppression project was fully implemented.

Key words: Alexander Creek, Chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, escapement goal, northern pike, *Esox lucius*, northern pike suppression, weir, sonar, ARIS, juvenile salmon, inclined plane trap

INTRODUCTION

BACKGROUND

Alexander Creek is a remote river system in the Northern Cook Inlet Management Area (NCIMA) that is accessible by boat or airplane. It is characterized as a low velocity, meandering, tea-colored system with numerous lakes and side sloughs and extensive wetlands (Yanusz and Rutz 2009; Jacobs 2014). There is a high diversity of fish species present in Alexander Creek including all 5 species of North American Pacific salmon (*Onchorynchus* spp.), rainbow trout (*O. mykiss*), Arctic grayling (*Thymallus arcticus*), Dolly Varden (*Salvelinus malma*), burbot (*Lota lota*), Arctic lamprey (*Lampetra camtschatica*), humpback whitefish (*Coregonus pidschian*), longnose sucker (*Catostomus catostomus*), stickleback (*Gasterosteus* spp.), and invasive northern pike (*Esox lucius*).

Alexander Creek was once one of the most productive Chinook salmon (*O. tshawytscha*) fisheries in the NCIMA. However, the Chinook salmon population severely declined from the late 1990s to the late 2000s (Figure 1). It went from being one of the most popular fishing locations in the NCIMA, with more than 26,000 angler-days of effort in the early 1990s, to closure of the Chinook salmon sport fishery beginning in 2008 by Alaska Board of Fisheries (BOF) action (Oslund et al. 2013; Table 1). Collapse of this fishery and subsequent closure has had a large negative economic impact. As many as 9 lodges with fishing guides, cabins, and boat rentals have closed (Yanusz and Rutz 2009). This also has affected float plane operators and license and fishing equipment sales.

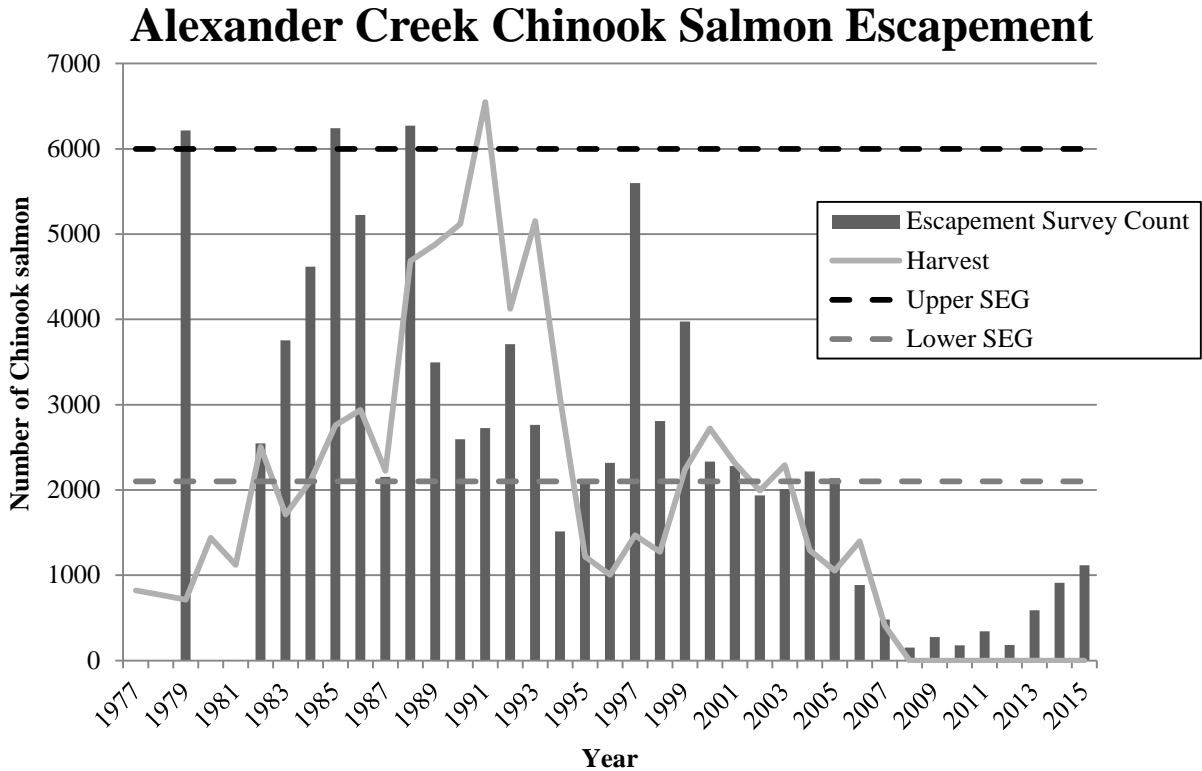


Figure 1.—Alexander Creek Chinook salmon escapement, sustainable escapement goals (SEGs), and harvest, 1977–2015.

Source: Oslund et al. 2017.

Table 1.—Regulatory history for the Alexander Creek Chinook salmon fishery, 1977–2015.

Year	Regulation
1977	All NCI- harvest >20 inches closed
1978	All NCI- harvest >20 inches closed
1979	Chinook salmon fishing open; seasonal limit of 5 over 20 inches
1980	Bag changed from 1 to 2 over 20 inches; only 1 over 28 inches
1981	Bag and possession changed back to 1 daily and 2 possession over 20 inches.
1986	Bag and possession changed to 2 per day and 4 possession over 16 inches; only 1 daily and 2 possession over 28 inches.
1987	Season extended from July 6 to July 13
1990	No seasonal limit
1992	Seasonal limit of 5 over 16 inches; bag and possession changed to 1 daily and 2 possession over 16 inches
1995	Bait prohibited; bag and possession 1 over 16 inches; fishing allowed 6 AM–11 PM; closed upstream of Trail Creek
1996	Season ends June 30; harvest allowed downstream of Granite Creek only
1999	Harvest area extended upstream of Granite Creek to Trail Creek
2008	Fishery closed
2011	Fishing closed for any species within one-half mile of the mouth of Alexander Creek May 1–July 13; “stock of concern” status established

Source: Oslund et al. 2017.

NORTHERN PIKE

Northern pike were illegally introduced to the Susitna River system in the early 1950s and were first observed in Alexander Creek in the late 1960s (Yanusz and Rutz 2009; Oslund and Ivey 2010). There is exceptional northern pike habitat throughout much of the Alexander Creek system, and they have since proliferated. Northern pike are thought to be largely responsible for the decline in Chinook salmon in this system because they prey on juveniles. Escapement and spawning distribution of adult Chinook salmon have been substantially reduced since aerial surveys began in 1979 (Figure 1). A spawning stronghold for Chinook salmon has remained in Sucker Creek, possibly because there are far fewer northern pike present. The habitat in Sucker Creek is less suitable to northern pike because there is higher water velocity and less of the preferred vegetated slack water available for this ambush predator. Little data exists for historical numbers of Alexander Creek coho salmon, but they are thought to have been heavily reduced by northern pike via juvenile predation as well.

The Alaska Department of Fish and Game (ADF&G) conducted a feasibility study of a northern pike suppression program on Alexander Creek in 2009 and 2010 (Oslund and Ivey 2010). Full implementation of this program began in 2011 with a grant from the Alaska Sustainable Salmon Fund and is ongoing. As of 2015, approximately 16,400 northern pike were removed from 67 side sloughs of Alexander Creek with set gillnets. Target reductions were for a depletion in catch rates (CPUE) by 85% per slough. This threshold was met in 68% of netted sloughs in 2011, 67% of sloughs in 2012, 50% of sloughs in 2013, 90% in 2014, and 71% in 2015 (Dunker 2014, 2015). Not all sloughs were netted each year because some become inaccessible during low water. Using radiotelemetry, investigators found there was minimal outmigration of adult northern pike from Alexander Lake (7.2% of 125 fish tagged in the spring were later relocated outside of Alexander Lake in the same year). Of the radiotagged fish that migrated out of the lake, all were later recaptured in suppression gillnets. An increase in the distribution of juvenile salmon also occurred from 2011 through 2015, as evidenced by minnow trap catches and stomach contents of captured northern pike (Dunker 2014, 2015).

There is no escapement goal for Alexander Creek coho salmon. The sustainable escapement goal (SEG) range for Chinook salmon returning to Alexander Creek is 2,100–6,000 fish as counted by aerial survey (Oslund et al. 2013). Chinook salmon escapements from aerial survey counts have been well under the lower bound of this goal since 2005 (Figure 1). In 2011, the BOF designated Alexander Creek Chinook salmon a stock of concern (Oslund et al. 2013; Table 1). In 2014, the Alaska State Legislature awarded funding for a dedicated long-term escapement monitoring project on Alexander Creek. Hiring for the project was not completed until well into the 2014 season, so the project was run for coho salmon only from July 15 through September 15. The project was operated for Chinook and coho salmon in 2015.

OBJECTIVES

Primary Objectives

The objectives for the Alexander Creek Chinook salmon weir project were as follows:

- 1) Count the number of adult Chinook and coho salmon in Alexander Creek that pass at river kilometer (RKM) 21 from mid-May through mid-September.

- 2) Estimate the age and sex composition of the adult Chinook and coho salmon escapement in Alexander Creek at RKM 21 from mid-May through mid-September such that the estimates are within ± 10 percentage points of the true values 90% of the time.

Secondary Objectives and Tasks

- 1) Identify and count all other species of fish that move through the live trap during weir operation.
- 2) Estimate mean length-at-age of Alexander Creek Chinook salmon.
- 3) Collect baseline genetic samples of all Pacific salmon species from Alexander Creek (100 samples per year).
- 4) Record water temperature, level, and clarity daily.
- 5) Locate a site suitable for Adaptive Resolution Imaging Sonar (ARIS) operation.
- 6) Index juvenile salmon with an inclined plane trap.

METHODS

ESCAPEMENT

A resistance-board (floating) weir, similar to those described in Bartlett (1996) and Tobin (1994), was used to enumerate Chinook and coho salmon escapement in Alexander Creek at RKM 21 (Figures 2, 3, and 4) from mid-July until mid-September in 2014 and mid-May until mid-September in 2015. An ARIS sonar system was on hand if high water prevented installation of a full resistance board weir. It was not necessary to use the ARIS in 2014 or 2015. This weir was operated primarily to count Chinook and coho salmon, but all other species were identified and counted.

Salmon

The Alexander Creek weir was outfitted with a live trap that salmon had to pass through to migrate upstream. Spaces between adjacent pickets on the weir and live trap were less than or equal to 38 mm (1.5 in) to prevent all but the smallest ocean-age-0 (jack) Chinook and coho salmon and small pink salmon from passing between pickets. Technicians counted all fish passing through the live trap during daylight hours. The front gate of the trap was closed when unattended. The trap was checked as often as necessary to prevent a substantial build-up of salmon (minimum 4 times per day including early morning and late evening). All salmon were counted individually using tally counters (Appendices A1 and A2).

Nontarget Species

Technicians identified, counted, and recorded all other fish species that moved through the trap while the weir was operational. All northern pike were removed and exterminated. In 2015, the length, sex, maturity, and stomach contents of all northern pike passing the weir were recorded (Appendix B1).

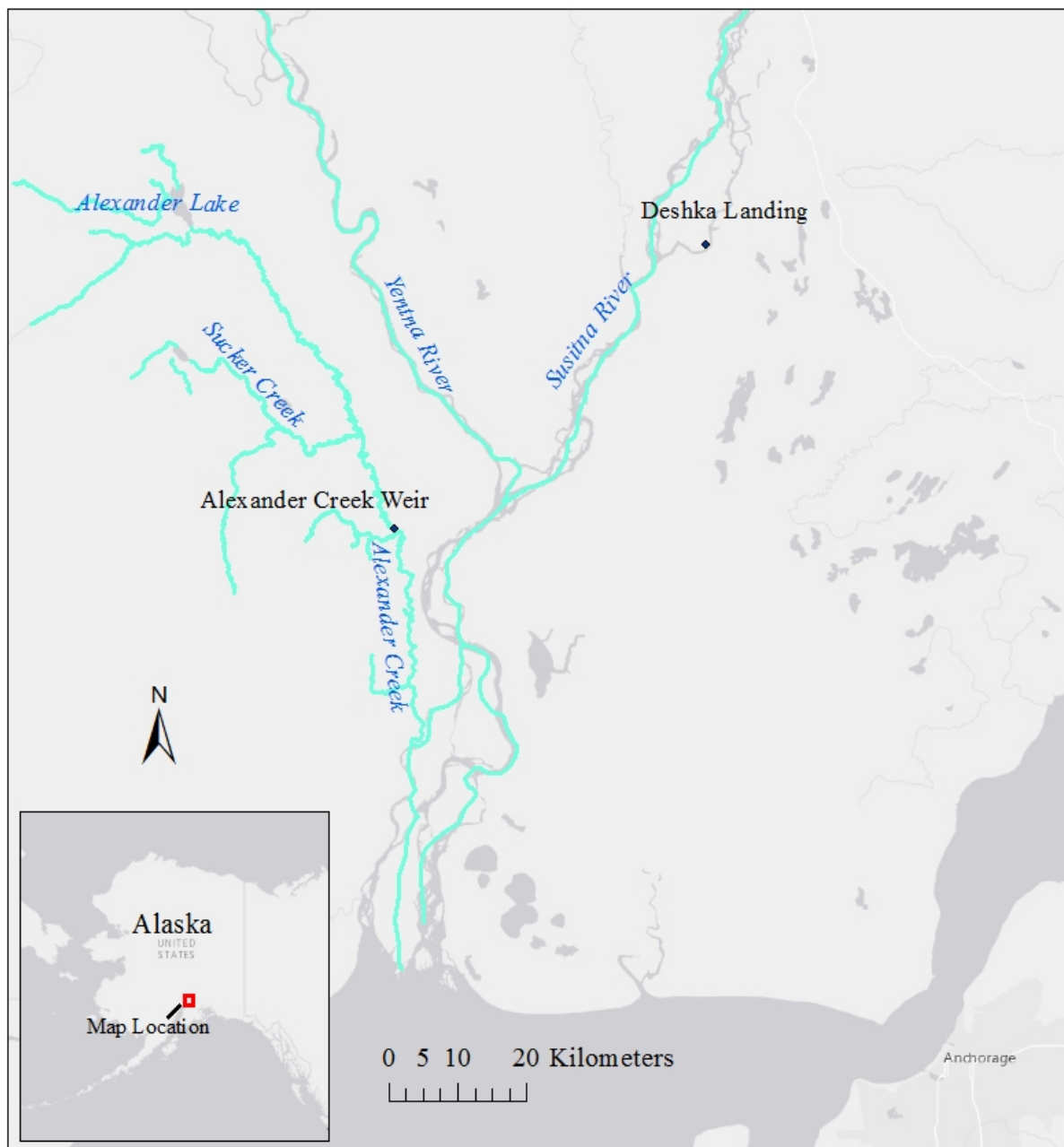


Figure 2.—Overview map of Alexander Creek system and lower Susitna River.

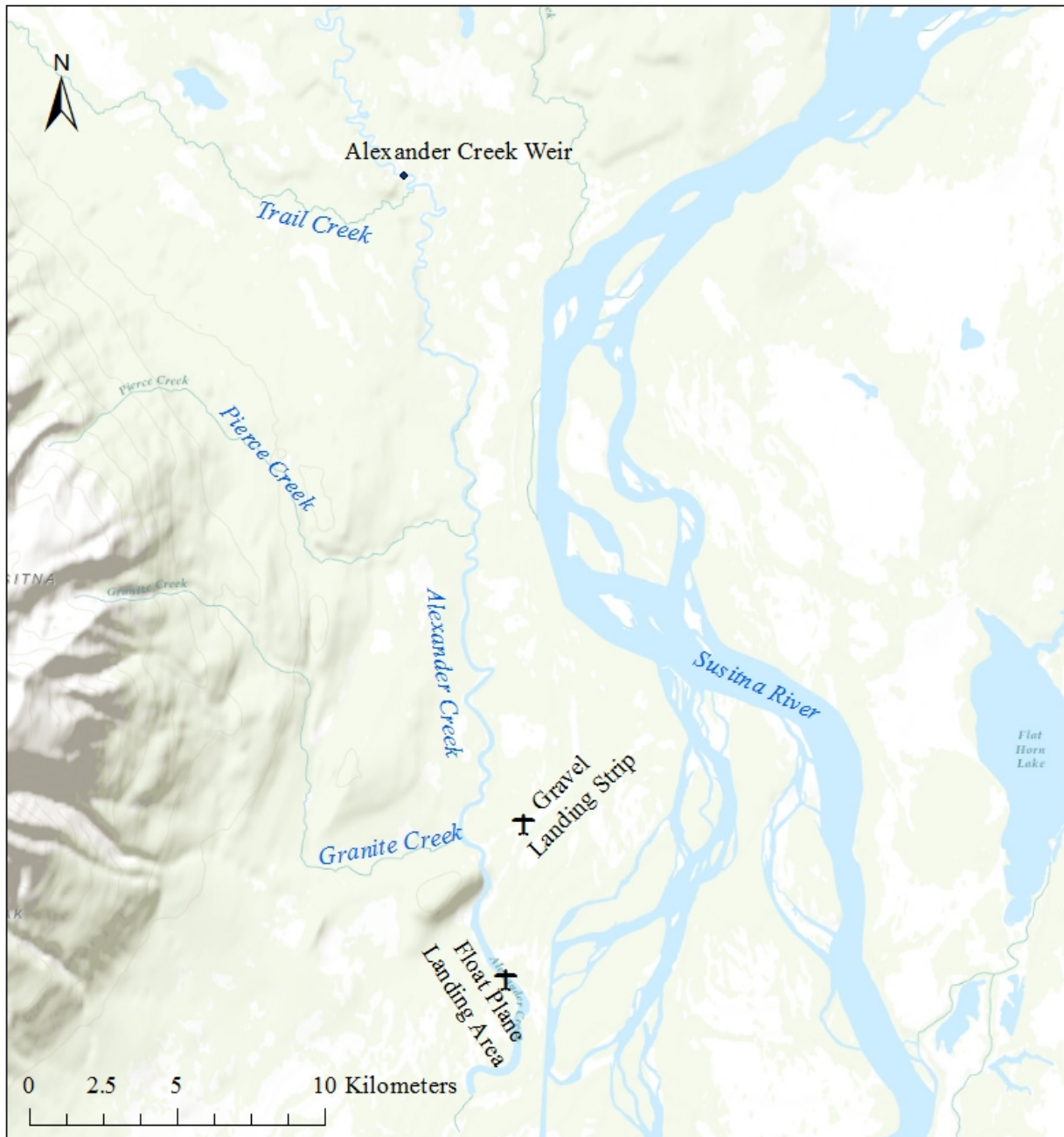


Figure 3.—Map of Alexander Creek showing location of weir site.



Figure 4.—Aerial view of the Alexander Creek weir site.

Note: Aerial image source is Matanuska-Susitna Borough (2011).

AGE AND SEX COMPOSITIONS

Chinook Salmon

The procedures outlined by Thompson (1987) were used to calculate the sample size for Chinook salmon age, sex, and length (ASL) composition, adjusting for a nonreadable scale rate of 25%. A sample size goal of 134 fish meets the objective criterion of ± 10 percentage points of the true value 90% of the time. Proportional sampling was used to obtain the 134 ASL samples per year. The target sampling rate was 1:4.

Coho Salmon

The procedures outlined by Cochran (1977) for estimating binomial proportions were used to calculate the sample size necessary to achieve the objective precision criteria set for coho salmon ASL composition in 2014. Coho salmon were not aged in 2015 because there is no escapement goal for coho salmon at Alexander Creek. Furthermore, the project will not be operated for coho salmon in future years, and there is a high degree of scale regeneration and uncertainty in coho salmon ageing.

Age, Sex, Length, and Genetic Tissue Sampling

Once technicians observed adequate numbers of Chinook or coho salmon in the trap, the downstream trap gate was closed. All fish in the trap were sampled to prevent selection bias, even if the number of fish exceeded the ratio or sample period goal.

Sampled fish were measured from mid eye to tail fork (METF) to the nearest 5 mm. Sex was determined by external physical characteristics, such as kype development in males or protruding ovipositor in females. For every sampled salmon, the axillary process was clipped and placed in a labeled bulk genetics bottle by species up to a sample size of 100 for the season. Sex, length, and genetic samples were recorded in waterproof notebooks while sampling.

Three scales from each sampled fish were taken from the preferred location (Welander 1940; Scarnecchia 1979) and placed sequentially on a gum card. The total number of fish sampled per day and card number(s) were recorded in waterproof notebooks while sampling.

Impressions from scales mounted on gum cards were made in cellulose acetate as described in Clutter and Whitesel (1956) and Scarnecchia (1979). The impressions were magnified 40× and viewed on a microfiche reader, and the ages were determined from growth patterns of the circuli. Ages were recorded in European notation (Jearld Jr. 1983).

WATER TEMPERATURE AND DEPTH

A protected glass thermometer was submerged in the river and attached to the live trap at the beginning of the season. The thermometer was read daily at 0900 and 1800 hours and temperature (°C) recorded. Depth (cm) was recorded daily at 0900 from a gauge mounted on the fish trap (Appendices C1–C2).

SONAR OPERATION LOCATION

An ARIS sonar was purchased at the outset of this project to ensure salmon could still be enumerated even if high water prevented successful weir installation or operation. In August 2014, 7 sites were investigated for possible ARIS operation. Desirable sites provide an unobstructed view across the river that can be covered by sonar and are easily accessible by staff. Sites were investigated by measuring a cross-section of river bathymetry and modelling the sonar beam pattern by adapting the methods of Faulkner and Maxwell (2009) to ARIS operation at each site.

JUVENILE SALMON INDEX

In support of the northern pike suppression project, a feasibility study of juvenile salmon monitoring was conducted in 2015. An inclined plane trap (Todd 1994) was operated from May 26 through June 14. The trap was anchored in gravel substrate with fence posts 150 m downstream of the weir on the south bank. The trap's proximity to the shoreline and height were adjusted as needed to maximize the water flow into the trap without risking a washout. The trap was checked 4 times per day; all fish were removed from the live box, identified, and enumerated (Appendix D1)

DATA REPORTING AND QUALITY CONTROL

All recorded data were e-mailed or called in to the project manager daily and entered into a spreadsheet. At the end of the field season, the data on the spreadsheet were reconciled with field notebooks by the project assistant.

DATA ANALYSIS

Age and Sex Compositions

For clarity, the following description and formulae were developed to estimate the age composition; however, estimates of sex composition were treated identically.

Age proportions for the escapement (\hat{p}_z), as well as the number of fish per age class (\hat{N}_z) and their estimated variances, were calculated using Equations 1–4.

The age proportions of the Chinook salmon escapement were estimated as follows:

$$\hat{p}_z = \frac{n_z}{n} \quad (1)$$

where \hat{p}_z is the estimated proportion of salmon passing the weir from age category z , n_z equals the number of fish sampled that were classified as age category z , and n equals the number of Chinook or coho salmon sampled for age determination.

The variance of \hat{p}_z was calculated by

$$\text{var}[\hat{p}_z] = \left(1 - \frac{n}{N}\right) \frac{\hat{p}_z(1 - \hat{p}_z)}{n - 1} \quad (2)$$

where N is the number of Chinook or coho salmon counted passing the weir.

The estimates of escapement by age categories in each sampling stratum were calculated as follows:

$$\hat{N}_z = N\hat{p}_z \quad (3)$$

with variance estimated as:

$$\text{var}[\hat{N}_z] = N^2 * \text{var}[\hat{p}_z]. \quad (4)$$

Mean Length-at-Age

For Chinook salmon mean length at age class k was estimated as follows:

$$\bar{l}_k = \frac{1}{n_k} \sum_{i=1}^{n_k} l_i \quad (5)$$

where

l_i = the length of fish i in a sample n_k and

n_k = the number of Chinook salmon of age class k .

The variance of the mean length-at-age class k was estimated as follows:

$$\text{var}(\bar{l}_k) = \frac{1}{n_k} \frac{\sum_{i=1}^{n_k} (l_i - \bar{l}_k)^2}{n_k - 1}. \quad (6)$$

RESULTS

ESCAPEMENT

The Alexander Creek weir was operated from July 16 through September 15 in 2014 and from May 20 through September 20 in 2015. The weir remained fish tight through the duration of both seasons. In 2014, the project was operated primarily to enumerate coho salmon. During this pilot season, 66 Chinook, 191 coho, 4,911 pink, 2,503 chum, and 6 sockeye salmon passed the weir. In 2015, the project was operated for both Chinook and coho salmon enumeration. During the second year of operation, 2,152 Chinook, 266 coho, 468 pink, 16,414 chum, and 11 sockeye salmon passed the weir.

RUN TIMING

The 2014 Alexander Creek coho salmon run was low relative to counts at other weirs in the area (Oslund et al. 2017) and sporadic. The midpoint of the 2014 coho salmon run occurred on August 17 (Figures 5; Appendix A1). The 2015 coho salmon run was also relatively low and sporadic. The midpoint of the 2015 run also occurred on August 17 (Figure 6; Appendix A2). The 2015 Chinook salmon run was much larger than the coho salmon runs in 2014 or 2015. The midpoint occurred on June 27 during a brief 3-day period when approximately 50% of the run migrated upstream. Chinook salmon passage was low and fairly steady after the midpoint until mid-August when a final push representing 10% of the total run occurred (Figure 7).

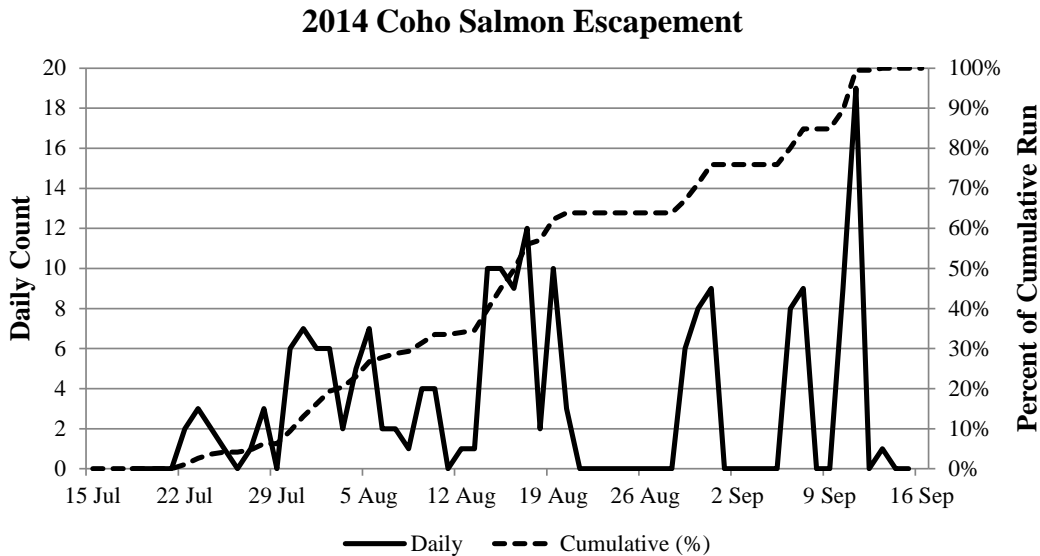


Figure 5.—Daily and cumulative coho salmon escapement to Alexander Creek in 2014.

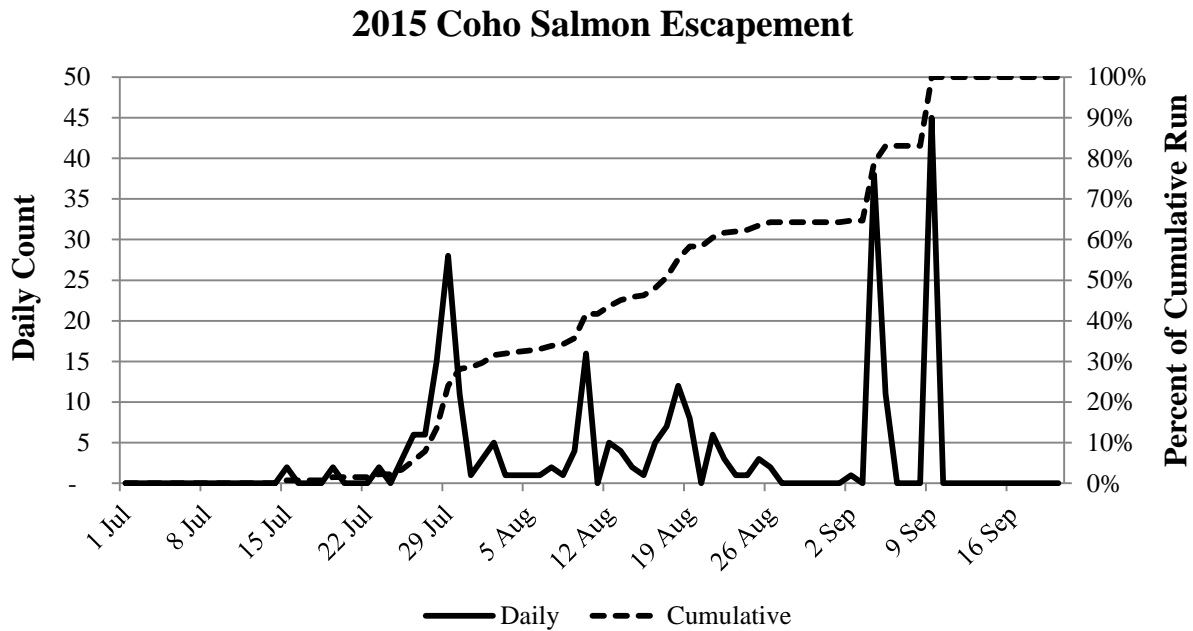


Figure 6.—Daily and cumulative coho salmon escapement to Alexander Creek in 2015.

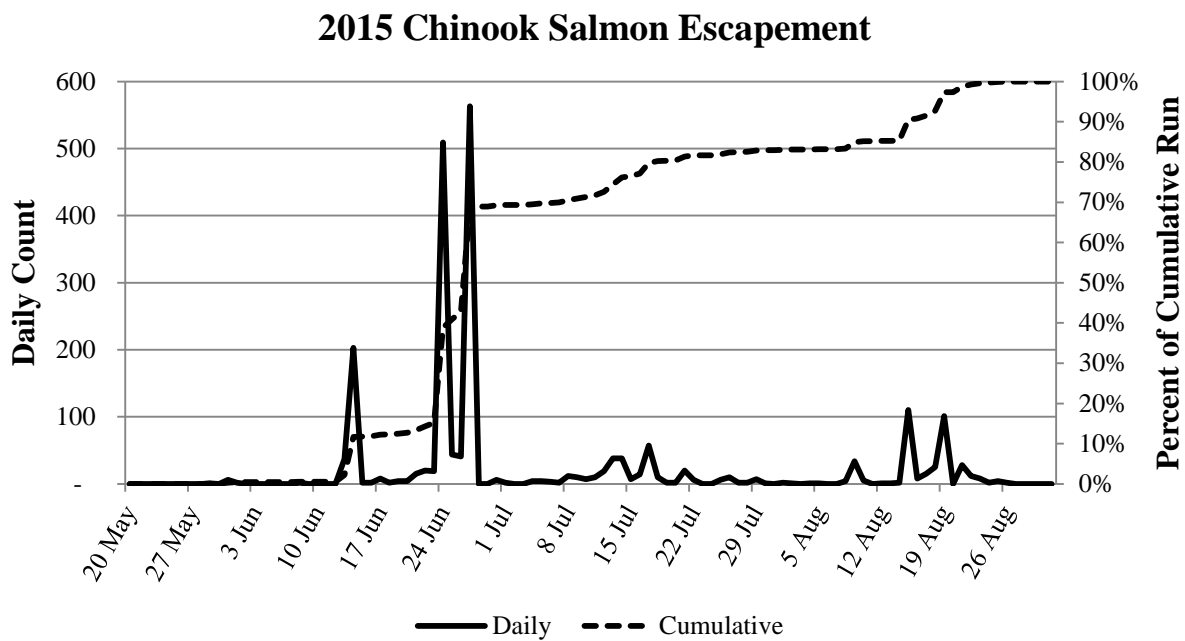


Figure 7.—Daily and cumulative Chinook salmon escapement to Alexander Creek in 2015.

AGE AND SEX

In 2014, the estimated age composition of the coho salmon run was 1.0% age-1.1 (SE 0.7%), 93.8% age-2.1 (SE 1.7%), and 5.1% age-3.1 (SE 1.6%) fish (Table 2). The estimated sex ratio of the total run was 36.1% female (SE 1.6%) (Table 2).

Table 2.—Estimated age and sex composition of the Alexander Creek coho salmon run in 2014.

Parameter	Age			Sex	
	1.1	2.1	3.1	F	M
<i>n</i>	1	92	5	53	94
Percent	1.02	93.88	5.10	36.05	63.95
SE (%)	0.71	1.70	1.56	1.91	1.91
95% CI lower	0.03	87.15	1.68	32.32	60.21
95% CI upper	5.55	97.72	11.51	39.79	67.68
Abundance	2	179	10	69	122
SE (abundance)	1.36	3.24	2.98	3.64	3.64

In 2015, the estimated age composition of the Chinook salmon run was 5.8% age-1.1 (SE 3.2%), 44.2% age-1.2 (SE 6.9%), 46.2% age-1.3 (SE 6.9%), and 3.9% age-1.4 (SE 2.7%) fish (Table 3). The average lengths-at-ages were as follows: 573 mm (SE 17.6) for age 1.1, 658 mm (SE 53.1) for age 1.2, 798 mm (SE 42.4) for age 1.3, and 935 mm (SE 42.4) for age 1.4 (Table 3). The estimated sex ratio of the total run was 51.5% female (SE 3.7%) (Table 3).

Table 3.—Estimated age, length-at-age, and sex composition for the Alexander Creek Chinook salmon run in 2015.

Parameter	Age				Sex ^a	
	1.1	1.2	1.3	1.4	F	M
<i>n</i>	3	23	24	2	91	114
Percent	5.77	44.23	46.15	3.85	51.45	48.55
SE (%)	3.23	6.87	6.90	2.66	3.66	3.66
95% CI lower	1.21	30.47	32.23	0.47	44.28	58.62
95% CI upper	15.95	58.67	60.53	13.21	41.38	55.72
Abundance	124	952	993	83	1,107	1,045
SE (abundance)	69.41	147.84	148.40	57.25	78.75	78.75
Average length (mm)	573	658	798	935	—	—
SE (length)	17.56	53.14	42.39	42.43	—	—

^a Overall percentage estimates were derived after temporal stratification.

GENETICS AND ENVIRONMENTAL DATA

Genetic baseline samples were collected from all salmon species in 2014 and 2015. In 2014, sample size goals of 100 per species were met for coho, pink, and chum salmon. Fifty-one Chinook and 6 sockeye salmon were sampled for genetic material. In 2015, sample size goals of 100 per species were met for Chinook, coho, pink, and chum salmon. Nine sockeye salmon were sampled for genetic material.

Both 2014 and 2015 were characterized by low, warm water for much of the season, with heavy rains and rising water in mid-September. Daily water level and water temperature are reported in Appendices C1 and C2.

SONAR OPERATION LOCATION

Although it was not necessary to operate ARIS sonar in 2014 or 2015, 7 sites were investigated for sonar operation. A cross-section of river bathymetry was measured and the sonar beam pattern was modeled by adapting the methods of Faulkner and Maxwell (2009) to ARIS operation at each site. Based on these site profiles, 2 top sites were selected. These sites were desirable because they offer an unobstructed view across the river that the sonar beam can cover completely, and they are in close proximity to the field camp. The first choice is the “Fox Den” site directly below the field camp. If this site does not work out for unforeseen reasons, the second choice is below the confluence of Trail Creek (Figure 4). Site profiles for these 2 sites are depicted in Appendices E1 and E2.

JUVENILE SALMON INDEX COUNTS

Although inclined plane trap catches were low, they were comparable to minnow trap catches conducted by the pike suppression project. In approximately 17 days of trap operation, catches comprised 45 juvenile Chinook, 0 coho, 33 chum, and 28 pink salmon, and 19 individual fish of other species (Appendix D1).

DISCUSSION

ESCAPEMENT

Coho salmon escapements were not surveyed on Alexander Creek prior to 2014. It is uncertain if escapement levels observed in 2014 and 2015 (191 and 266, respectively; Appendices A1 and A2) are normal, but they are much lower than the average historical Alexander Creek harvest of 1,683 fish (1980–2010; Oslund and Ivey 2010). No coho salmon were reported in the statewide harvest survey in 2014 or 2015 (Alaska Sport Fishing Survey database [Internet]. 1996– . Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (cited December 2016). Available from: <http://www.adfg.alaska.gov/sf/sportfishingsurvey/>). The escapements are also much lower than those observed in the Deshka River. The Deshka River is used for comparison because it is nearby, has similar physical characteristics, and long-term data are available. The recent 10-year average coho salmon count at the Deshka River weir was 21,640 (Lescanec *In prep*). Juvenile coho salmon are probably more susceptible to predation by northern pike because they typically spend an additional year rearing in the freshwater environment. An Oregon study demonstrated that juvenile coho salmon show a strong preference for slough habitat in the winter (Nickelson et al. 1992), which adds to their susceptibility to northern pike predation in the Alexander Creek system.

Chinook salmon aerial survey counts have been conducted on Alexander Creek every year since 1982 (Oslund et al. 2017). The 2015 count was 1,117 on July 15 and included 281 fish from the mouth of Alexander Creek up to the weir (Figure 1). Although some spawning occurs below the weir site, many of the fish counted below the weir by aerial survey probably passed the weir by the end of the run. The total aerial survey count equals 52% of the census at the weir (2,152 fish) and is similar to other aerial-to-weir count comparisons in the area (Ivey 2014; Lafferty 1997). The 2015 aerial count of 1,117 was more than double the recent 10-year average of 511 but less

than half of the long term (1979–2015) average of 2,396. Even though the escapement goal has not been achieved since 2005, escapement based on the aerial index has increased stepwise since 2012 (Figure 1). Other NCI streams have also shown an upward trend since 2012, although not stepwise (Oslund et al. 2017).

RUN TIMING

The 2014 Alexander Creek coho salmon run was low relative to others in the area (Deshka River, Little Su River, Fish Creek; Oslund et al. 2017) and sporadic. Alexander Creek coho salmon run timing was similar to that at Deshka River in 2014 where the midpoint of the run occurred 2 days earlier on August 15 (Lescanec *In prep*). In 2015, the midpoint of the Deshka River coho salmon run occurred on August 12, five days earlier than the Alexander Creek midpoint (ADF&G, unpublished data). Similar to most systems in the area, Alexander Creek coho salmon migrate when rain events cause rising and cooling water.

The 2015 Alexander Creek Chinook salmon run-timing midpoint (June 27) was 2 weeks later than the Deshka River Chinook salmon run where the midpoint occurred on June 13. However, the midpoint of the 2015 Deshka River Chinook salmon run occurred a week earlier than the long-term average of July 19 (ADF&G, unpublished data). The 2015 Alexander Creek run timing midpoint occurred at a later date partially because of the late push of approximately 250 Chinook salmon that occurred in mid-August. Nearly all of these fish were dark and were observed holding in deep pools within a mile of the weir site in the weeks prior to their passage. The low, warm water conditions probably influenced this behavior.

SCALE ABSORPTION

Of the 205 Chinook salmon scales collected in 2015, 20% were regenerated and 52% were partially absorbed, making them unreadable. The low, warm water probably exacerbated absorption. Effort will be made to collect more scales at the peak of the run in future years to alleviate this problem.

NORTHERN PIKE SUPPRESSION AND ADULT CHINOOK SALMON RETURNS

Full operation of the Alexander Creek northern pike suppression program began in 2011 (Dunker 2014). Age-1.3 Chinook salmon returning in 2015 were produced by the 2010 brood year. It is likely these juveniles would have emerged early in the spring (Groot and Margolis 1991) of 2011 and may have realized some benefit following the 2011 spring northern pike netting season. Age-1.2 Chinook salmon returning in 2015 would have emerged in the early spring of 2012 and perhaps gained additional benefit from a then fully-implemented northern pike suppression program. If there is a direct relationship between the northern pike suppression program and Chinook salmon adult returns in Alexander Creek, then it would be reasonable to expect increasing Chinook salmon runs in the coming years because the catch rates of northern pike declined from 2011 to 2015 (Dunker 2014, 2015).

STRAYING FROM YENTNA AND SUSITNA RIVERS

It is noteworthy that several Chinook and coho salmon that were tagged with visible dart tags at fish wheels on the Yentna and Susitna rivers (Cleary et al. 2014) were observed in Alexander Creek in 2015. Seven Chinook salmon tagged at Yentna and 5 tagged at the Susitna mainstem fishwheels passed the Alexander Creek weir in 2015. One coho salmon that was tagged at the Yentna fishwheels was caught by an angler in lower Alexander Creek. These fish initially would

have migrated up the Susitna River past the mouth of Alexander Creek, been captured approximately 31 RKM upstream, returned back down to the mouth of Alexander Creek, and then migrated upstream to the Alexander weir.

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APPENDIX A: ALEXANDER CREEK DAILY WEIR COUNTS

Appendix A1.–Daily escapement counts by species at Alexander Creek weir in 2014.

Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	Number	Species ^a	
15 Jul	–	–	–	–	–	–	–	Install rail
16 Jul	0	0	0	0	0	0		Weir fish tight 8:00 PM
17 Jul	0	0	0	0	0	0		No passage
18 Jul	0	0	25	0	0	0		
19 Jul	0	0	750	174	0	0		
20 Jul	0	0	970	212	0	0		
21 Jul	0	0	301	80	0	0		147 pink, 48 chum salmon through 9:00 AM
22 Jul	0	2	212	105	0	0		71 pink, 56 chum, 2 coho salmon, 1 northern pike through 9:00 AM; approx. 50–100 coho observed at mouth
23 Jul	0	3	661	337	0	2	NP	152 pink, 95 chum, and 0 coho salmon through 9:00 AM; 2 northern pike sacrificed
24 Jul	0	2	607	344	0	0		
25 Jul	2	1	221	194	0	0		
26 Jul	0	0	110	86	0	0		Few fish showing at Trail Creek
27 Jul	0	1	389	274	0	0		
28 Jul	0	3	206	109	0	0		Local at mile 9 says few coho salmon around
29 Jul	2	0	38	33	0	0		
30 Jul	1	6	88	49	1	0		Northern pike captured with landing net
31 Jul	3	7	40	58	0	0		1 coho salmon mortality
1 Aug	0	6	41	40	1	1	Lamprey	
2 Aug	2	6	51	34	0	2	AG	
3 Aug	1	2	5	16	1	0		
4 Aug	0	5	17	36	0	1	AG	20–30 downstream; 1 northern pike escaped from trap
	–	–	–	–	–	1	NP (killed)	
5 Aug	1	7	9	32	0	0		1 northern pike escaped from trap
6 Aug	1	2	19	45	0	0		
7 Aug	3	2	13	38	0	0		

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Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	Number	Species ^a	
8 Aug	3	1	19	48		1	NP	Northern pike escaped upstream
	–	–	–	–	–	1	AG	
9 Aug	5	4	40	17	0	2	NP	1 Northern pike (F) killed, 1 escaped upstream
10 Aug	6	4	10	40	0	0		
11 Aug	2		12	8	0	1	NP	1 Chinook salmon was chrome
12 Aug	4	1	5	11	1	0		Crew closed trap early during night count due to heavy rain and poor visibility
13 Aug	3	1	11	16	0	1	NP	M Northern pike, killed, empty stomach
14 Aug	2	10	12	13	0	0		
15 Aug	4	10	12	11	0	1	AG	Northern pike was small and escaped
	–	–	–	–	–	1	RBT	
	–	–	–	–	–	1	NP	
16 Aug	2	9	6	10	0	1	NP	Northern pike killed
17 Aug	10	12	7	6	0	3	RBT	
18 Aug	4	2	1	3	0	3	NP	3 female northern pike killed
19 Aug		10		2	0	0		Crew reports a large number of coho salmon in the mouth of Trail Creek
20 Aug	3	3	1	4	0	1	RBT	
	–	–	–	–	–	2	NP (killed)	
21 Aug	0	0	1	0	0	1	NP (killed)	30 to 50 coho salmon observed at Trail Creek
22 Aug	1	0	0	0	0	0		
23 Aug	0	0	0	0	0	1	RBT	
24 Aug	1	0	0	0	0	1	NP (killed)	
25 Aug	0	0	1	6	0	3	NP (killed)	
26 Aug	0	0	0	2	0	1	NP (killed)	1 large lamprey in northern pike stomach
27 Aug	0	0	0	0	0	0		
28 Aug	0	0	0	0	0	1	NP	

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Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	Number	Species ^a	
29 Aug	0	6	0	1	0	1	NP (killed)	Water rose 24 cm overnight; resistance boards raised
30 Aug	0	8	0	3	0	1	NP (killed)	
31 Aug	0	9	0	1	0	1	NP (killed)	
1 Sep	0	0	0	1	0	3	NP (killed)	
2 Sep	0	0	0	0	0	4	NP (killed)	
3 Sep	0	0	0	0	0	3	NP (killed)	
4 Sep	0	0	0	1	0	0		
5 Sep	0	0	0	1	0	1	NP (killed)	
6 Sep	0	8	0	0	1	1	NP (killed)	2 coho salmon were bright
7 Sep	0	9	0	0	0	1	NP	
	–	–	–	–	–	2	RBT	
8 Sep	0	0	0	0	0	0		
9 Sep	0	0	0	1	0	0		
10 Sep	0	9	0	0	1	0		1 bright coho salmon, 1 blush, others dark
11 Sep	0	19	0	0	0	2	NP (killed)	2 bright coho salmon, 1 blush, others dark
12 Sep	0	0	0	0	0	0		
13 Sep	0	1	0	0	0	0		1 coho salmon down while cleaning
14 Sep	0	0	0	1	0	0		
15 Sep	0	0	0	0	0	0		
16 Sep	0	0	0	0	0	0		Weir pulled
Total	66	191	4,911	2,503	6			

^a NP means northern pike; RBT means rainbow trout; AG means Arctic grayling.

Appendix A2.–Daily escapement counts by species at Alexander Creek weir in 2015.

Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	Number	Species ^a	
20 May	0	0	0	0	0	0		Weir fish tight 12:00 PM
21 May	0	0	0	0	0	0		
22 May	0	0	0	0	0	0		
23 May	0	0	0	0	0	0		
24 May	0	0	0	0	0	0		
25 May	0	0	0	0	0	0		
26 May	0	0	0	0	0	2	NP	All NP captured in 2015 were killed
27 May	0	0	0	0	0	0		
28 May	0	0	0	0	0	1	NP	
29 May	1	0	0	0	0	0		
30 May	0	0	0	0	0	2	NP	
31 May	6	0	0	0	0	0		
1 Jun	2	0	0	0	0	0		
2 Jun	0	0	0	0	0	0		
3 Jun	0	0	0	0	0	0		
4 Jun	0	0	0	0	0	0		
5 Jun	0	0	0	0	0	1	AG	
6 Jun	0	0	0	0	0	0		
7 Jun	0	0	0	0	0	1	RBT	
8 Jun	2	0	0	0	0	1	RBT	
9 Jun	0	0	0	0	0	0		
10 Jun	0	0	0	0	0	0		
11 Jun	0	0	0	0	0	0		
12 Jun	0	0	0	0	0	0		
13 Jun	37	0	0	0	0	0		More Chinook salmon likely to pass. Approximately 50–80 Chinook salmon still behind weir

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Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	Number	Species ^a	
14 Jun	203	0	0	0	0	1	RBT	
15 Jun	2	0	0	0	0	2	NP	
16 Jun	2	0	0	0	0	0		
17 Jun	8	0	0	0	0	0		
18 Jun	2	0	0	0	0	0		
19 Jun	4	0	0	0	0	0		
20 Jun	4	0	0	0	0	0		
21 Jun	15	0	0	0	0	0		
22 Jun	20	0	0	1	0	0		
23 Jun	19	0	0	0	0	0		1 Chinook salmon mortality on weir; had been sampled; sex was male
24 Jun	509	0	0	0	0	0		3 Chinook salmon passed with yellow floy (Yentna) tags
25 Jun	44	0	0	0	0	0		1 Chinook salmon passed with yellow floy (Yentna) tag
26 Jun	41	0	0	1	0	0		
27 Jun	563	0	0	6	0	0		2 Yentna tagged, 2 Susitna tagged Chinook salmon
28 Jun	0	0	0	0	0	0		
29 Jun	0	0	0	6	0	0		
30 Jun	6	0	2	1	0	1	NP	
1 Jul	2	0	0	19	0	1	NP	
2 Jul	0	0	0	14	0	1	NP	
3 Jul	0	0	0	19	0	0		
4 Jul	4	0	0	26	0	0		
5 Jul	4	0	0	109	0	2	NP	
6 Jul	3	0	0	177	0	0		
7 Jul	2	0	0	109	0	2	NP	
8 Jul	12	0	1	115	0	0		
9 Jul	10	0	1	113	0	0		

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Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	No.	Species ^a	
10 Jul	7	0	0	331	0	0		
11 Jul	10	0	1	489	0	0		
12 Jul	19	0	14	842	0	1	AG	
13 Jul	38	0	5	867	0	2	AG	
14 Jul	38	0	1	426	0	0		
15 Jul	7	2	3	645	0	0		
16 Jul	14	0	3	681	0	0		
17 Jul	57	0	40	2,164	0	0		1 Chinook salmon with mainstem tag (pink) passed
18 Jul	10	0	0	384	0	0		
19 Jul	2	2	3	269	0	0		
20 Jul	2	0	11	572	0	0		
21 Jul	20	0	32	857	0	2	NP	
	–	–	–	–	–	1	RBT	
22 Jul	6	0	17	645	0	2	RBT	
23 Jul	0	2	7	497	0	0		
24 Jul	0	0	11	306	0	1	NP	
25 Jul	6	3	34	673	0	1	RBT	
26 Jul	10	6	51	1,179	0	0		
27 Jul	2	6	21	535	0	1	NP	
	–	–	–	–	–	1	Longnose sucker	
28 Jul	2	15	35	817	0	0		
29 Jul	7	28	83	978	0	0		1 Chinook salmon with mainstem tag (pink) passed
30 Jul	1	11	13	263	1	0		
31 Jul		1	6	93	0	1	NP	
1 Aug	2	3	20	133	0	0		
2 Aug	1	5	14	134	0	0		1 coho salmon mortality

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Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	Number	Species ^a	
3 Aug	0	1	10	16	0	0		
4 Aug	1	1	4	4	0	0		
5 Aug	1	1	3	19	0	0		
6 Aug	0	1	6	92	0	1	NP	
7 Aug	0	2	3	105	1	0		
8 Aug	4	1	4	117	0	0		
9 Aug	34	4	3	162	0	0		
10 Aug	5	16	2	202	0	2	NP	
11 Aug	0	0	0	16	0	1	NP	
12 Aug	1	5	1	33	1	1	NP	
	–	–	–	–	–	1	AG	
13 Aug	1	4		5	0	0		
14 Aug	2	2	0	2	0	2	NP	
15 Aug	110	1	1	27	0	1	NP	
16 Aug	8	5	0	23	0	2	NP	
17 Aug	15	7	0	19	0	3	NP	
18 Aug	25	12	1	10	0	0		1 Yentna, 1 Susitna tagged Chinook salmon
19 Aug	101	8	0	13	1	2	NP	
20 Aug	0	0	0	0	0	0		
21 Aug	28	6	0	13	0	1	NP	
22 Aug	12	3	0	4	0	1	NP	
23 Aug	8	1	1	6	0	0		
24 Aug	2	1	0	0	0	1	NP	
	–	–	–	–	–	1	AG	
25 Aug	4	3	0	8	0	0		
26 Aug	2	2		4	1	4	NP	

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Date	Salmon					Other		Comments
	Chinook	Coho	Pink	Chum	Sockeye	Number	Species ^a	
27 Aug	0	0	0	3	0	0		
28 Aug	0	0	0	4	0	0		
29 Aug	0	0	0	0	0	1	NP	
	–	–	–	–	–	1	Burbot	
30 Aug	0	0	0	1	0	1	NP	
	–	–	–	–	–	1	AG	
31 Aug	0	0	0	0	0	0		
1 Sep	0	0	0	0	0	1	RBT	
2 Sep	0	1	0	4	0	1	NP	
3 Sep	0	0	0	0	0	0		
4 Sep	0	38	0	1	0	2	NP	
5 Sep	0	11	0	0	1	1	NP	
6 Sep	0	0	0	0	1	0		
7 Sep	0	0	0	0	0	0		
8 Sep	0	0	0	0	0	0		
9 Sep	0	45	0	4	2	3	NP	
10 Sep	0	0	0	0	2	1	NP	
11 Sep	0	0	0	0	0	1	NP	
12 Sep	0	0	0	0	0	2	NP	
13 Sep	0	0	0	0	0	0		
14 Sep	0	0	0	1	0	2	NP	
15 Sep	0	0	0	0	0	0		
16 Sep	0	0	0	0	0	1	NP	
17 Sep	0	0	0	0	0	1	NP	
18 Sep	0	0	0	0	0	0		
19 Sep	0	0	0	0	0	1	NP	
20 Sep	0	0	0	0	0	0		
21 Sep	0	0	0	0	0	0		Weir pulled
Total	2,152	266	468	16,414	11			

^a NP means northern pike; RBT means rainbow trout; AG means Arctic grayling.

**APPENDIX B: NORTHERN PIKE SAMPLED AT
ALEXANDER CREEK WEIR**

Appendix B1.–Northern pike sampled at Alexander Creek weir in 2015.

Date	Length	Maturity	Sex	Stomach contents ^a	Comments
25 May	592	M	F	3 PL, grass	worms
25 May	600	M	F	E	worms
28 May	631	M	F	2 PL	
30 May	646	M	M	weeds	worms
30 May	564	M	F	E	
1 Jun	692	M	M	water	
15 Jun	648	M	F	E	
15 Jun	621	M	M	E	
29 Jun	530	M	F	E	worms
29 Jun	619	M	F	E	
30 Jun	605	M	M	E	
2 Jul	600	M	M	3 KS, 2 SS, 1 SB	
5 Jul	531	M	M	E	
5 Jul	624	M	F	1 fish	
7 Jul	578	M	M	E	
7 Jul	704	M	F	E	
21 Jul	590	M	M	1 NP	
27 Jul	533	M	F	1 BB	
30 Jul	555	M	M	1 AG	
6 Aug	627	M	M	E	
10 Aug	708	M	F	1 RT, 1 mouse, 1 AG	
10 Aug	580	M	F	E	
11 Aug	598	M	M	1 macroinvertebrate	
12 Aug	610	M	M	E	
13 Aug	607	M	F	E	
16 Aug	541	M	F	1 BB	
16 Aug	528	M	M	E	
17 Aug	591	M	M	E	
17 Aug	687	M	F	1 NP	
17 Aug	645	M	F	E	
17 Aug	550	M	F	E	
19 Aug	588	M	F	E	
19 Aug	600	M	F	1 AG	
21 Aug	671	M	F	1 BB	
22 Aug	549	M	F	E	
24 Aug	670	M	F	E	
26 Aug	586	M	M	E	
26 Aug	595	M	F	E	
26 Aug	600	M	F	E	

-continued-

Appendix B1.–Page 2 of 2.

Date	Length	Maturity	Sex	Stomach contents ^a	Comments
26 Aug	685	M	M	E	
30 Aug	593	M	M	E	
2 Sep	619	M	F	E	
4 Sep	600	M	M	E	
4 Sep	670	M	F	E	
5 Sep	620	M	F	1 RT	
9 Sep	701	M	F	E	
9 Sep	670	M	M	E	
9 Sep	580	M	F	E	
10 Sep	685	M	F	E	Never spawned; eggs present in gonads
11 Sep	556	M	M	E	
12 Sep	686	M	M	E	
12 Sep	574	M	F	1 AG	Never spawned; eggs present in gonads
14 Sep	593	M	F	E	Never spawned; eggs present in gonads
14 Sep	745	M	F	E	

^a AG means Arctic grayling; BB means burbot; E means empty; KS means Chinook salmon; NP means northern pike; PL means pink salmon larvae; RT means rainbow trout; SB means stickleback; SS means coho salmon.

APPENDIX C: ALEXANDER CREEK ENVIRONMENTAL DATA

Appendix C1.–Daily water level and water temperature at Alexander Creek weir in 2014.

Date	Water level (cm)	Temperature			
		AM		PM	
		°C	°F	°C	°F
7 Aug	75.0	–	–	–	–
8 Aug	75.0	–	–	16.1	61.0
9 Aug	76.0	14.4	58.0	17.2	63.0
10 Aug	75.5	15.6	60.0	18.3	65.0
11 Aug	74.9	17.8	64.0	18.6	65.5
12 Aug	75.3	16.1	61.0	16.1	61.0
13 Aug	82.8	15	59.0	15.0	59.0
14 Aug	82.5	14.7	58.5	15.0	59.0
15 Aug	85.5	13.6	56.5	15.0	59.0
16 Aug	85.0	14.4	58.0	15.3	59.5
17 Aug	85.0	13.6	56.5	14.7	58.5
18 Aug	83.8	14.2	57.5	16.1	61.0
19 Aug	81.5	15	59.0	17.2	63.0
20 Aug	79.0	15	59.0	17.1	62.8
21 Aug	77.5	15	59.0	17.2	63.0
22 Aug	77.3	14.4	58.0	16.7	62.0
23 Aug	76.9	13.9	57.0	15.6	60.0
24 Aug	78.0	14.2	57.5	14.4	58.0
25 Aug	82.1	13.6	56.5	13.9	57.0
26 Aug	83.0	13.9	57.0	13.9	57.0
27 Aug	84.4	–	–	14.2	57.5
28 Aug	89.6	12.8	55.0	13.1	55.5
29 Aug	113.0	12.2	54.0	12.8	55.0
30 Aug	107.1	–	–	12.8	55.0
31 Aug	105.0	10.3	50.5	12.5	54.5
1 Sep	105.0	10.6	51.0	12.5	54.5
2 Sep	97.3	10.8	51.5	11.9	53.5
3 Sep	–	11.1	52.0	–	–
4 Sep	91.9	10.0	50.0	10.8	51.5
5 Sep	100.3	10.6	51.0	11.1	52.0
6 Sep	99.7	10.3	50.5	11.9	53.5
7 Sep	95.0	10.3	50.5	12.2	54.0
8 Sep	91.9	10.3	50.5	11.1	52.0
9 Sep	89.7	10.8	51.5	11.4	52.5
10 Sep	97.8	11.1	52.0	11.9	53.5
11 Sep	97.0	10.3	50.5	12.5	54.5
12 Sep	99.0	11.7	53.0	12.2	54.0
13 Sep	122.0	11.7	53.0	12.8	55.0
14 Sep	121.6	11.7	53.0	12.2	54.0
15 Sep	122.4	11.1	52.0	11.7	53.0

Note: The water level gauge was installed on August 7 and thermometer was installed on August 8; an en dash means no data were collected.

Appendix C2.–Daily water level and water temperature at Alexander Creek weir in 2015.

Date	Water level (cm)	Temperature			
		AM		PM	
		°C	°F	°C	°F
20 May	–	–	–	–	–
21 May	112.1	13.0	55.4	10.0	50.0
22 May	108.4	14.0	57.2	16.0	60.8
23 May	100.0	14.0	57.2	14.0	57.2
24 May	105.0	12.0	53.6	14.5	58.1
25 May	103.0	14.0	57.2	15.0	59.0
26 May	98.0	13.5	56.3	15.0	59.0
27 May	96.0	13.5	56.3	16.0	60.8
28 May	94.0	14.0	57.2	16.0	60.8
29 May	91.0	14.5	58.1	17.0	62.6
30 May	88.5	16.0	60.8	19.0	66.2
31 May	86.0	17.0	62.6	20.5	68.9
1 Jun	83.0	18.0	64.4	20.0	68.0
2 Jun	79.5	17.0	62.6	16.0	60.8
3 Jun	80.0	14.5	58.1	15.5	59.9
4 Jun	80.0	14.0	57.2	14.0	57.2
5 Jun	88.0	12.5	54.5	13.0	55.4
6 Jun	85.0	12.5	54.5	13.0	55.4
7 Jun	87.0	13.0	55.4	15.5	59.9
8 Jun	85.0	14.0	57.2	14.0	57.2
9 Jun	81.0	13.5	56.3	13.5	56.3
10 Jun	82.0	12.5	54.5	15.0	59.0
11 Jun	79.0	13.0	55.4	14.0	57.2
12 Jun	78.0	13.5	56.3	15.5	59.9
13 Jun	75.0	15.0	59.0	18.0	64.4
14 Jun	73.0	16.5	61.7	20.0	68.0
15 Jun	70.0	17.5	63.5	21.0	69.8
16 Jun	67.0	19.0	66.2	22.0	71.6
17 Jun	65.0	19.0	66.2	22.0	71.6
18 Jun	63.0	20.0	68.0	24.0	75.2
19 Jun	61.0	20.5	68.9	23.5	74.3
20 Jun	59.0	19.5	67.1	21.5	70.7
21 Jun	58.0	19.0	66.2	20.0	68.0
22 Jun	58.0	18.0	64.4	22.0	71.6
23 Jun	57.0	18.0	64.4	22.0	71.6
24 Jun	56.0	18.5	65.3	22.0	71.6
25 Jun	56.0	19.0	66.2	20.5	68.9

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Date	Water level (cm)	Temperature			
		AM		PM	
		°C	°F	°C	°F
26 Jun	55.0	18.5	65.3	19.5	67.1
27 Jun	54.0	17.5	63.5	18.5	62.3
28 Jun	54.0	17.5	63.5	19.0	66.2
29 Jun	53.0	18.0	64.4	20.0	68.0
30 Jun	53.0	17.5	63.5	20.0	68.0
1 Jul	52.0	17.0	62.6	19.0	66.2
2 Jul	53.0	16.0	60.8	18.0	64.4
3 Jul	56.0	15.0	59.0	19.0	66.2
4 Jul	56.0	16.5	61.7	18.0	64.4
5 Jul	56.0	17.0	62.6	21.0	69.8
6 Jul	55.0	19.0	66.2	22.0	71.6
7 Jul	53.0	19.5	67.1	21.0	69.8
8 Jul	53.0	18.0	64.4	20.5	68.9
9 Jul	52.0	17.5	63.5	19.0	66.2
10 Jul	52.0	17.5	63.5	20.5	68.9
11 Jul	50.0	17.5	63.5	20.0	68.0
12 Jul	50.0	18.0	64.4	20.0	68.0
13 Jul	53.0	18.0	64.4	20.0	68.0
14 Jul	56.0	17.0	62.6	20.5	68.9
15 Jul	55.0	17.0	62.6	21.0	69.8
16 Jul	55.0	16.5	61.7	17.5	63.5
17 Jul	60.0	15.5	59.9	16.5	61.7
18 Jul	61.0	14.0	57.2	18.0	64.4
19 Jul	59.0	15.5	59.9	19.5	67.1
20 Jul	57.0	17.0	62.6	21.0	69.8
21 Jul	55.0	18.0	64.4	20.0	68.0
22 Jul	53.0	17.5	63.5	18.0	64.4
23 Jul	53.0	17.0	62.6	20.0	68.0
24 Jul	52.0	18.0	64.4	22.5	72.5
25 Jul	50.0	19.0	66.2	20.0	68.0
26 Jul	49.0	18.5	65.3	19.0	66.2
27 Jul	53.0	17.0	62.6	18.0	64.4
28 Jul	51.0	17.0	62.6	18.0	64.4
29 Jul	55.0	17.0	62.6	19.0	66.2
30 Jul	57.0	16.0	60.8	19.5	67.1
31 Jul	57.0	17.0	62.6	21.0	69.8

-continued-

Date	Water level (cm)	Temperature			
		AM		PM	
		°C	°F	°C	°F
1 Aug	55.0	17.0	62.6	22.0	71.6
2 Aug	53.0	19.0	66.2	23.0	73.4
3 Aug	51.0	19.0	66.2	24.0	75.2
4 Aug	49.0	20.0	68.0	25.0	77.0
5 Aug	48.0	20.0	68.0	24.0	75.2
6 Aug	47.0	19.0	66.2	23.0	73.4
7 Aug	46.0	19.0	66.2	21.5	70.7
8 Aug	46.0	19.0	66.2	20.5	68.9
9 Aug	45.0	18.0	64.4	18.0	64.4
10 Aug	48.0	16.5	61.7	18.0	64.4
11 Aug	48.0	15.5	59.9	18.0	64.4
12 Aug	46.0	16.0	60.8	18.0	64.4
13 Aug	45.0	16.0	60.8	19.0	66.2
14 Aug	45.0	17.5	63.5	20.5	68.9
15 Aug	44.0	17.0	62.6	18.0	64.4
16 Aug	46.0	16.0	60.8	17.0	62.6
17 Aug	48.0	15.5	59.9	16.0	60.8
18 Aug	51.0	15.0	59.0	19.0	66.2
19 Aug	50.0	16.0	60.8	20.0	68.0
20 Aug	49.0	15.0	59.0	17.5	63.5
21 Aug	49.0	15.0	59.0	18.0	64.4
22 Aug	48.0	14.0	57.2	17.0	62.6
23 Aug	47.0	14.0	57.2	16.5	61.7
24 Aug	46.0	13.0	55.4	16.0	60.8
25 Aug	45.0	15.5	59.9	16.5	61.7
26 Aug	45.0	15.0	59.0	16.0	60.8
27 Aug	45.0	15.0	59.0	16.0	60.8
28 Aug	44.0	12.0	53.6	14.0	57.2
29 Aug	44.0	11.5	52.7	13.0	55.4
30 Aug	44.0	10.0	50.0	11.0	51.8
31 Aug	43.0	10.0	50.0	12.0	53.6
1 Sep	43.0	9.5	49.1	11.0	51.8
2 Sep	42.0	10.0	50.0	12.0	53.6
3 Sep	42.0	12.0	53.6	12.0	53.6
4 Sep	46.0	12.0	53.6	13.0	55.4
5 Sep	51.0	12.0	53.6	12.5	54.5
6 Sep	49.0	12.5	54.5	14.0	57.2

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Date	Water level (cm)	Temperature			
		AM		PM	
		°C	°F	°C	°F
7 Sep	48.0	13.0	55.4	15.0	59.0
8 Sep	48.0	13.0	55.4	14.0	57.2
9 Sep	54.0	13.0	55.4	14.0	57.2
10 Sep	62.0	13.0	55.4	14.0	57.2
11 Sep	63.0	12.0	53.6	13.0	55.4
12 Sep	64.0	12.0	53.6	12.0	53.6
13 Sep	80.0	10.0	50.0	11.0	51.8
14 Sep	73.0	10.5	50.9	11.0	51.8
15 Sep	80.0	10.5	50.9	11.0	51.8
16 Sep	90.0	10.0	50.0	11.0	51.8
17 Sep	82.0	10.0	50.0	11.0	51.8
18 Sep	82.0	9.0	48.2	9.5	49.1
19 Sep	87.0	8.0	46.4	9.0	48.2
20 Sep	83.0	8.0	46.4	8.5	47.3
21 Sep	80.0	7.0	44.6	—	—

Note: An en dash means no data were collected. Temperature was recorded to the nearest 0.5°C.

APPENDIX D: INCLINED PLANE TRAP CATCH

Appendix D1.–Inclined plane trap catch of juvenile salmon and other species.

Date	Catch by species									
	Salmon ^a					Stick- -back ^b	Lamprey ^c	Eulachon ^d	Suckers ^e	Sculpin ^f
	Chinook	Coho	Chum	Pink	Sock- eye					
24 May										
25 May										
26 May	2		3	1			2			
27 May			1				2		1	
28 May	1						1			
29 May			1	1		1				
30 May	2		1	5		1	2			
31 May			2	3		1				
1 Jun	1		2			1			1	
2 Jun	1		3			1		1		
3 Jun	1		1	1						
4 Jun	6		1	5		1				
5 Jun	3		8	8						
6 Jun	7		6							
7 Jun	2		3	3						
8 Jun	3									
9 Jun	3					1				
10 Jun	5		1							1
11 Jun	3									
12 Jun	3									
13 Jun	1			1		1				
14 Jun	1									
15 Jun										
Total	45	0	33	28	0	8	7	1	2	1

^a All juvenile.

^b *Gasterosteus cognatus*.

^c *Lampetra camtschatica*.

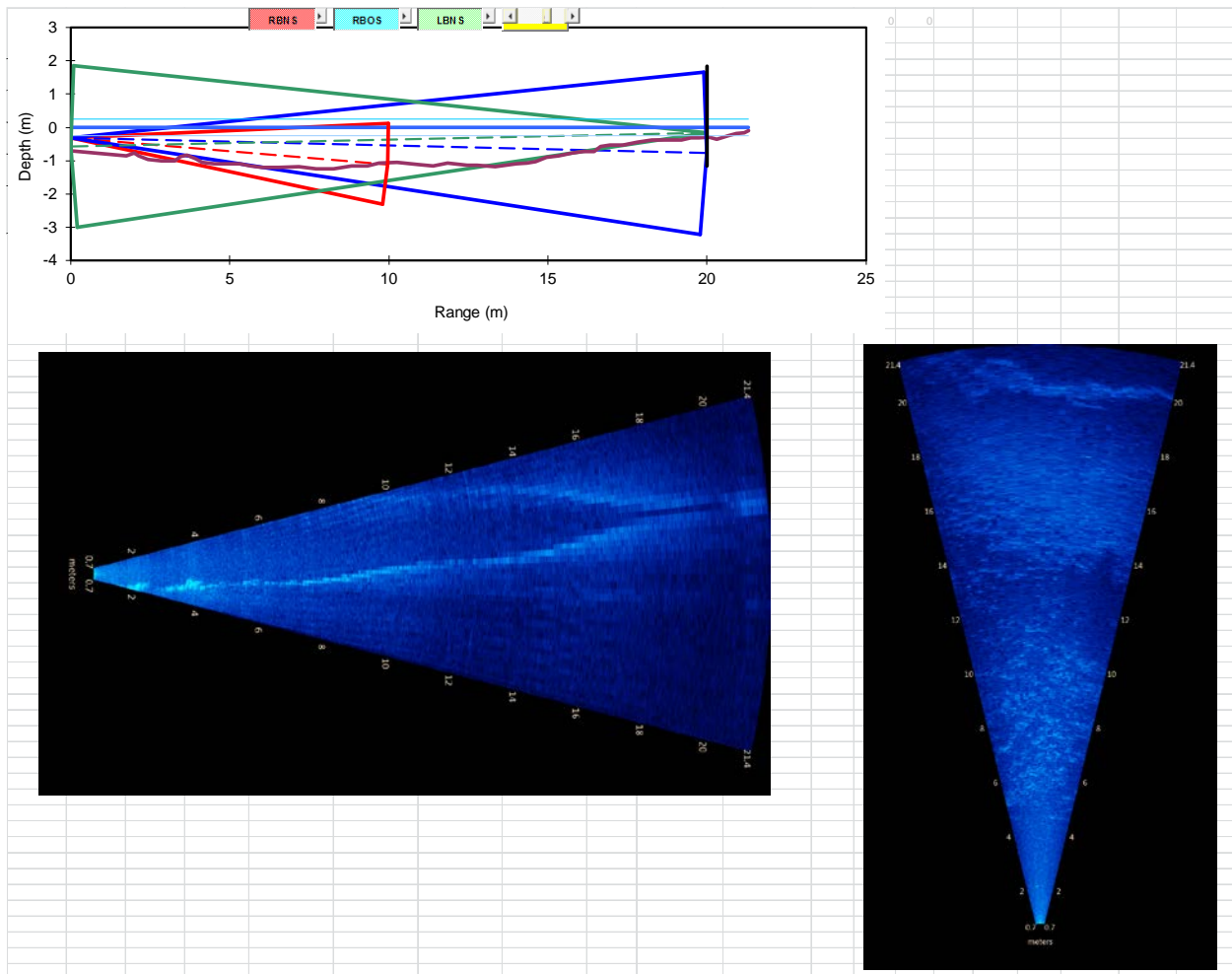
^d *Thaleichthys pacificus*.

^e *Catostomus catostomus*.

^f *Cottus cognatus*.

APPENDIX E: ARIS SITE PROFILES

Appendix E1.–“Fox Den” site profile including bathymetry and ARIS sonar modeled beam pattern.



Appendix E2.–“Trail Creek” site profile including bathymetry and ARIS sonar modeled beam pattern.

